DOCUMENTATION OF DECISION-AIDING SOFTWARE:

EVAL FUNCTIONAL DESCRIPTION

DECISIONS AND DESIGNS INC.

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November 1979

N00014-79-C-0069

ADVANCED DECISION TECHNOLOGY PROGRAM

CYBERNETICS TECHNOLOGY OFFICE
DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
Office of Naval Research • Engineering Psychology Programs

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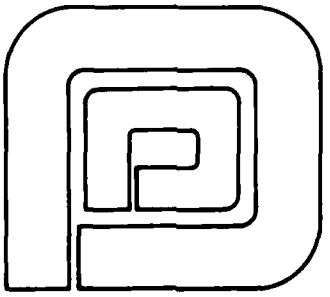
Sponsored by

Defense Advanced Research Projects Agency
ARPA Order 3469

November 1979



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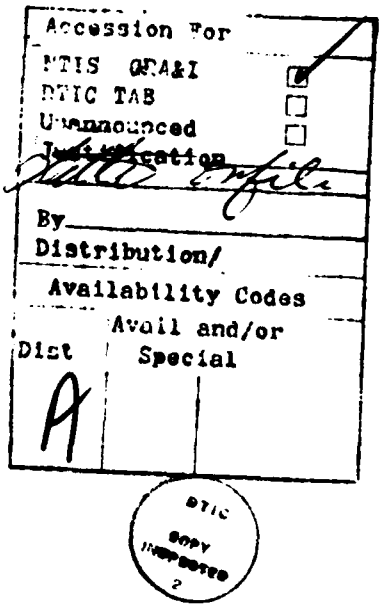


FIGURES

EVAL FUNCTIONAL DESCRIPTION

1.0 INTRODUCTION

1.1 Purpose of the Functional Description

This Functional Description provides a technical delineation of the specific functions that EVAL must perform. It serves as a formal basis for mutual understanding between the functional designer of the system and the software development personnel. Together with the EVAL System Specification, it serves as the basic documentation for systems development and implementation.

1.2 References

1.2.1 Barclay, S., et al. Handbook for Decision Analysis. Technical Report 77-6-30. McLean, Virginia: Decisions and Designs, Inc., September 1977.

1.2.2 Allardyce, Linda B.; Amey, Dorothy M.; Feuerwerger, Phillip H.; Gulick, Roy M. Documentation of Decision-Aiding Software: EVAL Users Manual. McLean, Virginia: Decisions and Designs, Inc., November 1979.

1.2.3 Allardyce, Linda B.; Amey, Dorothy M.; Feuerwerger, Phillip H.; Gulick, Roy M. Documentation of Decision-Aiding Software: EVAL System Specification. McLean, Virginia: Decisions and Designs, Inc., November 1979.

1.3 Terms and Abbreviations

1.3.1 EVAL - EVAL, the name of the system, is an abbreviation for Evaluation, reflecting the system's major area of applicability.

1.3.2 Terms - Standard mathematical notations and decision-analytic terminology are used throughout this Functional Description. Decision-analytic terms are defined when they are first encountered. Reference 1.2.1 provides more detail on decision analysis, should it be desired.

2.0 SYSTEM SUMMARY

2.1 System Description

EVAL is a decision-analytic, model-building software system. Its general purpose is to aid decision makers by providing them a capability to construct, store, retrieve, exercise, and refine evaluation models of complex decision problems they face.

EVAL uses multi-attribute utility (MAU) theory as the organizing framework for information processing. MAU assessment is the methodological tool with which the decision maker defines and exercises EVAL models to evaluate alternative systems. The MAU assessment model is employed in decision-analytic studies to quantify and assess the overall relative value of very complex multi-attributed alternatives that differ across a large number of characteristics.

The MAU model is hierarchical in nature, starting with the overall top-level criterion for which a comparative evaluation score is desired. That factor is successively decomposed into its component criteria in descending levels of the hierarchy such that each successive lower-level criterion is more specific than those at the preceding level. At the lowest level of the hierarchy are the criteria for which specific scores will be assessed for the alternatives by the user. For evaluating the alternative systems, the criteria at the lowest level address the more easily understood operational or technical attributes of the systems under evaluation. For evaluating funding programs, they may be the specified attributes of potential program performance.

EVAL permits the user to build and exercise MAU assessment models. The overall objective of EVAL is to ensure that the ultimate evaluation choice is coherent: a choice that is fully consistent with the decision maker's own value structure and belief about the future performance of the alternative systems or programs under consideration. For a complete description of the purpose and use of EVAL, see EVAL Users Manual, reference 1.2.2.

2.2 Design Objectives

The EVAL system is designed to be used interactively by end users who are relatively unsophisticated with respect to computer technology. Accordingly, the design satisfies two human-factors objectives: EVAL is a menu-driven system, and it is generally forgiving of procedural errors by the user.

In addition, to facilitate the production of the program specification and coding necessary to implement EVAL at a physical site, the system is designed in a hierarchically structured and modular fashion. The logical structure of EVAL is contained in EVAL Systems Specification, reference 1.2.3.

3.0 DETAILED CHARACTERISTICS

The fundamental product of EVAL is a multi-attribute utility (MAU) assessment model. The EVAL system enables the user to create, store, retrieve, exercise, and refine MAU assessment models interactively.

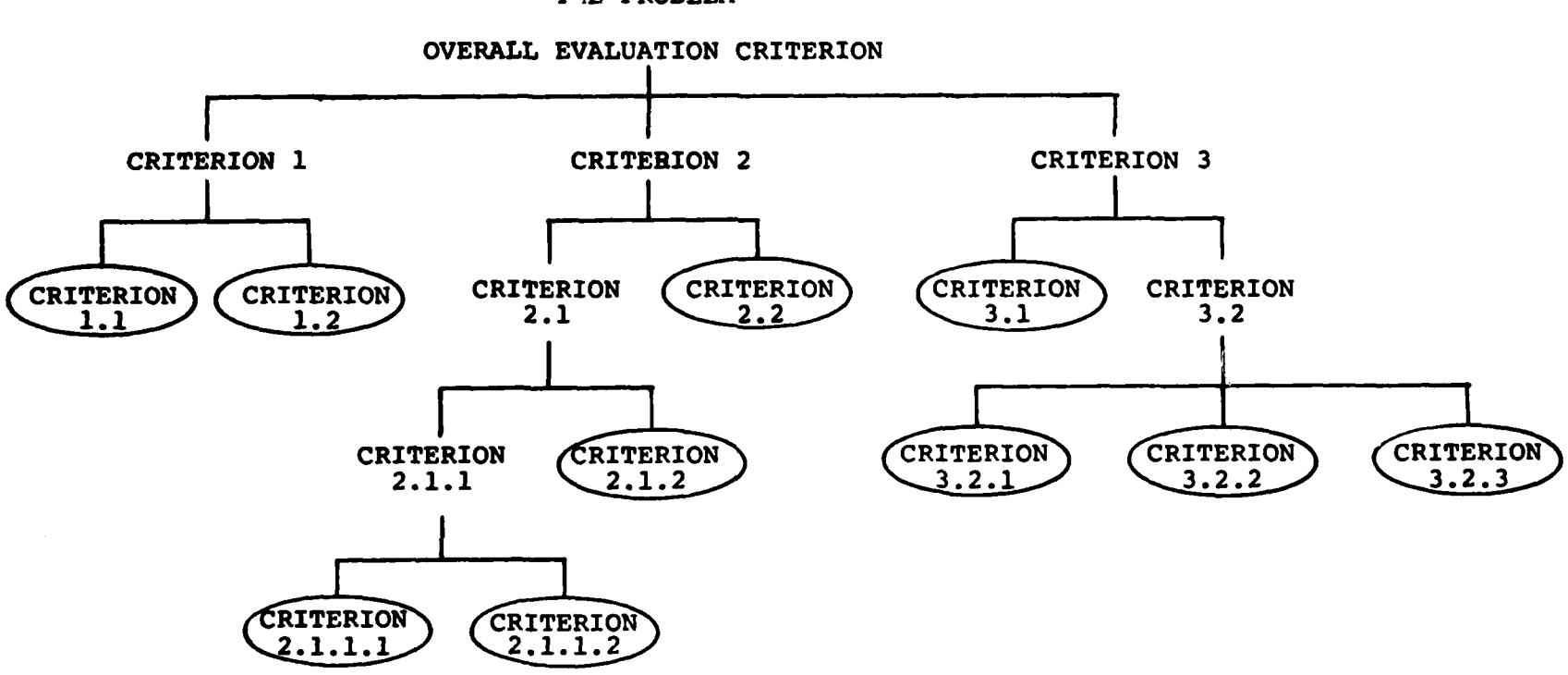
All of the specific functions that EVAL performs are related to the EVAL MAU assessment model. Therefore, in order to establish a frame of reference for understanding the EVAL functions, it is necessary to begin with a detailed description of the format, inputs, and outputs of the MAU model. A description of the specific functions that EVAL performs appears in Section 4.0.

3.1 Model Description

Each MAU model created by the user has a unique label, and each is constructed by using the same generic hierarchical format. A typical model format is represented graphically in Figure 3-1. The format always consists of all of the following elements which, when completely specified, uniquely define an EVAL MAU model.

3.1.1 The evaluation problem - A short label defining the problem. This label distinguishes the MAU model as a whole and is used to store and retrieve the model.

3.1.2 Criteria - A set of criteria constituting overall evaluation. The overall evaluation criterion is decomposed into component criteria which themselves may be decomposed. Those criteria which are not further decomposed comprise the bottom-level criteria. The bottom-level criteria are circled in Figure 3-1.



NOTE: The alternatives are directly compared and scored only with respect to the circled (bottom-level) criteria.

Figure 3-1

THE FORMAT OF A MULTI-ATTRIBUTE UTILITY ASSESSMENT MODEL

3.1.3 Alternatives - A list of the alternative systems or programs that the decision maker must evaluate. Each alternative is given an appropriate label.

3.1.4 Utility scores - A list of the scores representing the relative utility of each alternative evaluated with respect to each bottom-level criterion. A utility is a number between zero and one that represents the relative degree of satisfaction of an alternative with respect to a particular bottom-level criterion. Utilities are normally expressed as percentages of complete satisfaction. For example, three alternative systems might be scored 50 100 0 with respect to criterion 2.1.2. The scoring indicates that, relative to only the three alternatives, the second is the best, the third is the worst, and the first is midway between the two with respect to that criterion.

3.1.5 Relative importance weights - These weights describe the relative importance of the lower-level criteria into which a higher-level criterion is decomposed. A set of weights is assigned for each decomposition; one weight for each criterion. Every criterion except for the overall (top-level) criterion must be assigned an importance weight. The weights themselves represent percentages of the whole and must sum to 100%. However, unnormalized weights may be specified, in which case EVAL will then normalize them to sum to 100%. For example, unnormalized weights of 50 100 50 would be normalized to 25 50 25.

3.1.6 Data identification numbers - These are assigned to each criterion and describe how all of the criteria are logically related. This numerical labeling process is shown in Figure 3-1. For example, the subfactors of criterion 1 have data identification numbers 1.1 and 1.2.

The model is completely and uniquely defined when all of the above factors are specified.

3.2 Results of the Model

The input specifications describing the model can be processed to produce the following results of interest to the user.

3.2.1 Overall results - The overall utility associated with each alternative. For each alternative, the overall utility is obtained by weighting and adding the utility scores assigned to the bottom-level criteria and continuing to aggregate from bottom to top. Scores for any specified higher-level criterion are calculated and displayed in the same manner.

3.2.2 Normalized weights - A set of vectors corresponding to the relative importance weights of the criteria. A set of relative importance weights is assigned to the criteria comprising any specific higher-level factor. These weights are normalized into percentages by dividing each assigned weight by the sum of the weights of the component criteria. That is,

$$W_i = \frac{w_i}{\sum_j w_j}$$

where W is the normalized weight of criterion i, and w is the unnormalized weight. In calculating results, the normalized weights, expressed as fractions, rather than the relative importance weights, are used.

3.2.3 Intermediate results - A set of utilities assigned to any of the intermediate criteria during the calculation of the overall result.

3.2.4 Cumulative weights - A set of weights corresponding to the relative importance weights of the criteria. These are calculated as follows: The top-level criteria comprising the overall evaluation have cumulative weights equal to their normalized weights. At the next lower level, the criteria are assigned a cumulative weight computed by multiplying the normalized weight by the cumulative weight of the factor to which it is attached, and dividing the product by 100. This process is continued down through the structure until all criteria have been assigned cumulative weights. The cumulative weight (CUMWT) indicates the relative importance of the criterion to the overall evaluation.

3.3 Sensitivity Analysis

Another set of results can be obtained by using the EVAL software. An n x 11 matrix can be generated that displays eleven overall score vectors. The matrix is a sensitivity analysis, calculated as follows: The user identifies one criterion of interest and assigns the maximum and minimum cumulative weights that it may assume. EVAL varies the cumulative weight of the criterion in increments the size of one-tenth of the difference between the maximum and minimum weights. The other weights in the model maintain their previously assigned proportional relationships with one another. That is,

$$W_j = \frac{w_j(100 - W_i)}{100 - w_i}$$

where

W_i = a variable, the test weight of the criterion of interest, varied incrementally.

W_j = a variable, the correct test weight for any other criterion as W_i is varied.

w_i = a constant, the originally specified weight of criterion i.

w_j = a constant, the originally specified weight of criterion j.

Normally, the alternative that receives the highest overall utility will change as the criterion weight is incremented from W_{min} to W_{max}. The points of change are referred to as threshold points and are easily noted in the matrix. Figure 3-2 shows an example threshold matrix. Note that the alternative having the highest utility is identified with an asterisk.

1.2 PERFORMANCE CURRENT CUMWT: 55.00

WEIGHT	A	B	C	D	E
.0	63	54	50	68	74*
10.0	63	56	52	66	73*
20.0	64	59	54	64	72*
30.0	64	62	56	62	71*
40.0	65	64	58	60	70*
50.0	65	67	60	58	69*
60.0	66	70*	62	56	68
70.0	66	72*	63	54	67
80.0	67	75*	65	52	66
90.0	67	78*	67	49	65
100.0	68	81*	69	47	64

Figure 3-2
SENSITIVITY ANALYSIS

4.0 EVAL FUNCTIONS

EVAL is designed to perform the basic functions described below. The functions are divided into two separate categories, STRUCTURE and RUN, each designed to perform various functions. A description of the detailed logical design of the EVAL functions is contained in the manual, EVAL System Specification, reference 1.2.3.

4.1 Functions Performed Both in STRUCTURE and RUN

4.1.1 Maintain a library of EVAL models - Store various evaluation models, filed by their associated labels.

4.1.2 Load an existing EVAL model - Display the labels of those evaluation models stored in the model library, and permit the user to retrieve any desired model. The loaded model is referred to as the current model.

4.1.3 Save the current model - Permit the user to add the current model to the model library, or to replace an existing model with the current model.

4.2 Functions Performed only in STRUCTURE

4.2.1 Create a new EVAL model - Permit the user to create a new model, which then becomes the current model. The user creates a model by specifying the elements listed in Section 3.1. Alternatively, the user may create separate sections, or branches of the model individually, later adding those sections to the overall model while creating it.

4.2.2 Revise the structure of an existing model - Permit the user to make changes to the logical structure of the current model. The user may:

a. add new criteria to the existing structure;

b. prune (remove entire sections from) an existing structure;

c. edit criterion names;

d. alter the logical relationship among existing criteria by changing data identification numbers; and

e. remove any criterion.

4.2.3 Develop the structure of a newly created or edited model - Organize the criterion data identification numbers and labels in a structural format to allow for permanent storage of the model, and for the input of utility scores and importance weights as part of the RUN functions.

4.2.4 Print a review sheet - Print out the structure of the model thus permitting the user to review the current model to determine whether any structural revision is required. A sample review sheet is shown in Figure 4-1.

4.3 Functions Performed only in RUN

4.3.1 Supply new values to the current model - Permit the user to supply an entire set of criteria weights (which the computer automatically normalizes) or bottom-level criterion utility scores to the current model.

0 OVERALL
1 TRAINING
1.1 INDIV DEF
1.1.1 TRNG SYSTM
1.1.1.1 TIME
1.1.1.2 QUALITY
1.1.1.2.1 RELEVANCE
1.1.1.2.2 MOTIVATION
1.1.1.3 AVAIL
1.1.2 INSTRUCTOR
1.2 MIS DEG,T
1.2.1 INDIV SKL
1.2.2 TEAM SKL
1.2.3 EMPLOY SKL
1.3 QUALIFIED
1.3.1 QUAL OPPTY
1.3.2 MST STDS
2 PERSONNEL
2.1 PERS DEF
2.1.1 REENL RATE
2.1.2 PERS RETN
2.2 E-5/9 PCT
2.2.1 TRNG
2.2.2 CAR REENL
2.3 MIS DEG,P
2.3.1 CRIT SKILL
2.3.2 MGT SKILL
2.3.3 PERF QUAL
3 EQUIPMENT
3.1 EQ DEF
3.1.1 REP MAINT
3.1.1.1 MAINT SKL
3.1.1.2 MAINT AIDS
3.1.2 EQ DESIGN
3.1.3 PREV MAINT
3.1.3.1 MAINT SKL
3.1.3.2 MAINT AIDS
3.2 MIS DEG,E
3.2.1 EQ REDNCY
3.2.2 EMPLOY SKL
3.3 PCT OP RDY
3.3.1 NOR,MAINT
3.3.2 NOR,SUPPLY
4 MATERIEL
4.1 MAT SHORT
4.1.1 SUP SKL
4.1.2 MAT USE
4.2 PCT ALLOW
4.2.1 EQUIP USE
4.2.2 EXT SPT
4.3 MIS DEG,M
4.3.1 EMPLOY
4.3.2 EQUIP DES

Figure 4-1
A SAMPLE REVIEW SHEET

4.3.2 Print a worksheet - Provide a printed worksheet on which the user may record an entire set of weights and utility scores. A sample worksheet is shown in Figure 4-2.

4.3.3 Display the results of the current model - Permit the user to examine the structure and content of the current model by displaying:

a. normalized criteria weights;

b. cumulative criteria weights;

c. bottom-level criteria utility scores;

d. overall and intermediate aggregated utility scores;

e. criteria names; and

f. hierarchical relationships of the criteria within the overall model structure.

A printed version of any of these results may also be obtained.

4.3.4 Perform sensitivity analyses - Permit the user to test the sensitivity of the overall result of the current model to changes in the importance weights of individual criteria at any level except the top factor.

4.3.5 Revise values assigned to the current model - Permit the user to make changes to the current model. The user may revise:

a. criteria importance weights; and

b. bottom-level criteria utility scores.

ENTER DATA IN THE ORDER: NOW FUT

0 - OVERALL (WT:____)
1 - TRAINING (WT:____)
1.1 - INDIV DEF (WT:____)
1.1.1 - TRNG SYSTM (WT:____)
1.1.1.1 - TIME (WT:____) ____ ____
1.1.1.2 - QUALITY (WT:____)
1.1.1.2.1 - RELEVANCE (WT:____) ____ ____
1.1.1.2.2 - MOTIVATION (WT:____) ____ ____
1.1.1.3 - AVAIL (WT:____) ____ ____
1.1.2 - INSTRUCTOR (WT:____) ____ ____
1.2 - MIS DEG,T (WT:____)
1.2.1 - INDIV SKL (WT:____) ____ ____
1.2.2 - TEAM SKL (WT:____) ____ ____
1.2.3 - EMPLOY SKL (WT:____) ____ ____
1.3 - QUALIFIED (WT:____)
1.3.1 - QUAL OPPTY (WT:____) ____ ____
1.3.2 - MST STDS (WT:____) ____ ____
2 - PERSONNEL (WT:____)
2.1 - PERS DEF (WT:____)
2.1.1 - REENL RATE (WT:____) ____ ____
2.1.2 - PERS RETN (WT:____) ____ ____
2.2 - E-5/9 PCT (WT:____)
2.2.1 - TRNG (WT:____) ____ ____
2.2.2 - CAR REENL (WT:____) ____ ____
2.3 - MIS DEG,P (WT:____)
2.3.1 - CRIT SKILL (WT:____) ____ ____
2.3.2 - MGT SKILL (WT:____) ____ ____
2.3.3 - PERF QUAL (WT:____) ____ ____
3 - EQUIPMENT (WT:____)
3.1 - EQ DEF (WT:____)
3.1.1 - REP MAINT (WT:____)
3.1.1.1 - MAINT SKL (WT:____)
3.1.1.2 - MAINT AIDS (WT:____) ____ ____
3.1.2 - EQ DESIGN (WT:____) ____ ____
3.1.3 - PREV MAINT (WT:____)
3.1.3.1 - MAINT SKL (WT:____)
3.1.3.2 - MAINT AIDS (WT:____) ____ ____
3.2 - MIS DEG,E (WT:____)
3.2.1 - EQ REDNCY (WT:____) ____ ____
3.2.2 - EMPLOY SKL (WT:____) ____ ____
3.3 - PCT OP RDY (WT:____)
3.3.1 - NOR,MAINT (WT:____) ____ ____
3.3.2 - NOR,SUPPLY (WT:____) ____ ____
4 - MATERIEL (WT:____)
4.1 - MAT SHORT (WT:____)
4.1.1 - SUP SKL (WT:____) ____ ____
4.1.2 - MAT USE (WT:____) ____ ____
4.2 - PCT ALLOW (WT:____)
4.2.1 - EQUIP USE (WT:____) ____ ____
4.2.2 - EXT SPT (WT:____) ____ ____
4.3 - MIS DEG,M (WT:____)
4.3.1 - EMPLOY (WT:____) ____ ____
4.3.2 - EQUIP DES (WT:____) ____ ____

Figure 4-2

A SAMPLE WORK SHEET